DO POWER OUTAGES HURT EXPORT PERFORMANCE? EVIDENCE FROM A FIRM-LEVEL SURVEY

Abhijit Sen Gupta* and **Prakash Singh†**

Abstract

Power outages reduce the competitiveness of firms by increasing the cost of production and engendering loss of output, thereby making firms less likely to survive external competition. This paper evaluates the impact of power outages on firms' decision to enter the export market and on export propensity, measured as the share of exports in overall sales. The analysis indicates that power outages have a significant negative impact on the decision to export, with firms that face power outages exhibiting 9 to 13 percent lower chances of getting into the export market. We find that firms facing power outages have significantly lower export propensity than firms with adequate access to power. While large firms exhibit the highest probability of entering the export market as well as export propensity, followed by medium-sized and small firms, power outages reduce the probability of entering the export market and export propensity across all firm sizes.

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Nontechnical Summary

Exports have been found to bolster economic development in emerging markets through a variety of channels. These include allowing domestic producers to access a larger market and achieving economies of scale in the production process, encouraging specialization, and learning-by-doing, thereby raising productivity, and sharing a mutually reinforcing relationship with other public goods such as innovation, research and development and foreign direct investment. However, entering the export market is not preordained and depends upon a wide range of factors that influence firms' ability to face external competition. Factors include characteristics such as size, age, use of foreign inputs, infrastructure, institutional quality, and access to finance.

We evaluate the extent to which power disruptions hurt firms' export performance. Power disruptions can dent firms' competitiveness and export performance in a variety of ways, such as by raising of the cost of production, causing loss from production foregone, damaging a partially completed product and generating costs associated with recalling or disposing of faulty products. Theoretically, export performance and power disruptions can have a mutually reinforcing relationship. While power disruptions may undermine firms' export performance, better-quality power may be served in areas where firms that export or aim to export are concentrated.

We establish that power disruptions, measured as power outages, exert a strong negative influence on firms' decision to enter the export market and on the proportion of firms' output marketed as exports. The results are robust even after accounting for the presence of this bidirectional relationship, correcting for the presence of many non-exporting firms and controlling for other factors that have been found in the literature to impact firms' export performance. Firms facing power outages exhibit nine to 13 percent lower chances of getting into the export market, and power outages reduce the proportion of export output by three to four percentage points.

Our paper adds to the literature on the impact of power outages, which has mainly focused on the impact on other aspects of firm performance, including sales, costs, productivity, and employment. The paper evaluates the extent to which the impact of power outages on exports varies with firm size. While large firms have the highest probability of entering the export market as well as export propensity, followed by medium-sized and small firms, across all firm sizes power outages have an adverse impact on both the decision to enter the export market and on the share of output that can be exported.

I. Introduction

The role of infrastructure in influencing trade across borders largely remained unexplored until the late 1990s. Since then, the broad consensus has been that improved infrastructure is associated with better export performance through multiple channels. The relationship can be bidirectional. For example, better infrastructure facilities may be provided in areas where exporting firms are concentrated, such as an export processing zone. Some exporting firms may have better managerial and financial resources to negotiate the regulatory issues associated with the provision of infrastructure facilities. A number of other factors, such as institutional quality and governance, may also have a bearing on infrastructure and export performance.[1] We examine the effect of power disruption on firms' export performance, measured as the decision to enter the export market and the share of output that is exported. We hypothesize that power outages are a significant barrier in firms' entry to the export market and negatively impact the share of exported output.

A large body of literature has acknowledged the various channels through which exports facilitate economic growth:

(1) Exports allow domestic producers to access a larger market for their goods and services, thereby enabling producers to achieve economies of scale.
(2) Exports encourage specialization and learning-by-doing, thereby raising productivity not only in the tradable sector but also in the non-tradable sector.
(3) Exports share a mutually reinforcing relationship with several other public goods that reinforce growth, such as innovation, research, and development (R&D) and foreign direct investment (Aghion et al., 2018; Cintio et al., 2017; and Ahmed et al., 2018).

Infrastructure can help reduce trade costs through a variety of channels. The expansion or improvement of infrastructure such as transport linkages within or across countries or reliable quality of power at affordable rates can help reduce the marginal cost of production, thereby raising productivity and helping firms achieve an efficient scale of production. Firms benefitting from higher productivity and efficiency can increase their sales in domestic and external markets. Better connectivity infrastructure can help reduce the distribution margins between producers and consumers, thereby creating opportunities for trade that benefit them. Improved connectivity infrastructure eases market catchment and access to broader labor markets, improving competitiveness.

[1] Better institutional quality and governance can help improve the quality of infrastructure by reducing transaction costs among the various actors involved in developing infrastructure by reducing information asymmetry, lowering risks, and restricting actions of interest groups (Rodrik et al., 2004). High institutional quality facilitates trade by leveling the playing field, as individual economic agents cannot abuse market power by monopolizing trade in their favor and thereby restrict flows as a result of rent-seeking activities.

There are direct monetary outlays on various infrastructure services such as communication, transport, ports, among others, which depend not only on the distance between trading partners but also the cost and quality of the services. Timely delivery of products has also become an important factor, especially in industries that are serviced by global value chains (GVCs) and have adopted just-in-time practices. Weak infrastructure, such as inferior quality of power, poor road quality and inadequate port-handling capacity, may create uncertainty about product delivery time and quality. The greater the uncertainty about delivery time, the more inventory is required to meet demand, which, in turn, requires additional working capital.

However, much of the literature on the effect of infrastructure on trade has focused on country-level impact. Country-level aggregation masks important heterogeneity among firms. They can vary across dimensions, including productivity and scale, which are likely to be influenced by factors such as production technology, management practices, firms' organization, and product characteristics. Thus, cross-country differences in productivity can emanate from heterogeneity in production units and misallocation of resources across firms. The country-level aggregate productivity depends on the distribution of the firms, including the length of the tail. The infrastructure required by a large firm to improve its engagement in international trade is likely to be different from that needed by a small or medium-sized firm. Similarly, different industries will have diverse infrastructure requirements to be able to engage with global markets.

A key infrastructure input to production is power. World Bank Enterprise Survey respondents identified the lack of access to reliable electricity as the most important infrastructure-related constraint.[2] Power disruptions impose a nontrivial loss on firms by adversely impacting their productivity and sales and reducing their competitiveness. The reliability of power supply is likely to influence production possibilities of firms and affect their longer-term choices, including the likelihood of engaging in the export market. Many firms adapt to unreliable power infrastructure by resorting to alternatives, which entail a cost of adaptation significantly higher than the cost of disruption. The most common strategy is to use diesel-powered backup generators, which, apart from increasing emissions of air pollutants and greenhouse gases, come at a considerable cost; self-generated electricity is on average three times more expensive than electricity purchased from the grid (Steinbuks and Foster, 2010). The cost reduces the competitiveness of firms, diminishing their potential to engage in global markets.

Inadequate power supply substantially increases initial investments to start a business. The impact is more severe for small firms; Adenikiniju (2008) estimated that small firms must spend 10-20 percent of start-up costs on self-generated power. The situation is even direr in some energy-intensive sectors, with small firms shut out of the market because they cannot finance the additional investment needed for self-generated

[2] For details, please refer to section III of this Working Paper.

power. The result is overall loss of efficiency and entrepreneurship, denting overall competitiveness.

The paper contributes to the literature by examining the impact of power outages on export orientation using cross-country firm-level data, a relationship that, to our knowledge, has been relatively unexplored. We evaluate the effect of power outages on firms' decision to enter the export market and on firms' export propensity, defined as the share of export sales in total sales. Export performance and power outages can have a bidirectional relationship. While power outages may improve firms' export performance, it may also be the case that better-quality power is served in areas where firms that export or aim to export are concentrated. In our estimation, we check for the presence of the bidirectional relationship by using appropriate instruments, thus adding to the literature on power outage impact on other aspects of firms' performance, including sales, costs, productivity, and employment.

The empirical results indicate that power outages have a significant negative impact on the decision to export. Firms facing power outages exhibit nine to 13 percent lower chances of getting into the export market, even after accounting for the bidirectional relationship. Firms facing power outages show significantly lower export propensity than firms that have adequate access to power. The paper concludes that while large firms have the highest probability of entering the export market and export propensity, followed by medium-sized and small firms, power outages dent the probability of entering the export market as well as the export propensity of firms of varying sizes by three or four percentage points.

The rest of the paper is structured as follows. Section II briefly reviews the literature on infrastructure's impact on firms' performance. Section III presents a primer on the extent of power outages across different regions and the relationship between power outages and export propensity across different sectors and firm sizes. In section IV, we evaluate the impact of power outages on the decision to export and on export propensity across different specifications and estimation strategies. Finally, section V summarizes the key findings and outlines selected policy recommendations.

II. A Brief Review of the Literature

The impact of infrastructure on different aspects of economic development has been well documented. The direct contribution of infrastructure to output emanates from various infrastructural inputs such as information and communication, transport, and energy as essential parts of the production process. Aschauer (1989) tested this premise by including infrastructure capital as an input in the production function and identified a positive relationship between infrastructure, output, and productivity. Subsequent studies have found that infrastructure aids economic development through a variety of channels, including (1) reducing the cost of doing business (Roller and Waverman, 2001), (2) improving communication efficiency (Cieślik and Kaniewska, 2004), (3) enhancing labor productivity (Hulten et al., 2006) and (4) facilitating the adoption of innovation (Czernich et al., 2011).

The impact of infrastructure on trade volume was largely unexplored until the late 1990s. Bougheas et al. (1999) were among the first to attempt to model the resource cost of infrastructure formation and demonstrate that improvement in infrastructure in selected European Union countries, by reducing transport costs, can enhance trading opportunities. Infrastructure was found to have a positive impact on the volume of trade after controlling for distance and gross domestic product. Nordås and Piermartini (2004), focusing on 138 advanced and developing economies, found that infrastructure quality has a significant and large impact on bilateral trade flows, with port infrastructure having the largest impact. Limao and Venables (2001), analyzing 103 countries, showed that deterioration in infrastructure raises transport costs and reduces trade volumes, while Celbis et al. (2014) applied meta-analysis techniques and estimated that a one percent increase in infrastructure would increase exports by about 0.6 percent and imports by about 0.3 percent, and thereby improve net exports if exports and imports were of similar magnitude. Portugal-Perez and Wilson (2012) found that improvement in infrastructure quality across 101 countries significantly affects export growth, with impact decreasing with income level.

Selected papers have evaluated characteristics of firms that make them more amenable to export: innovation (Greenhalgh, 1990; Buxton et al., 1991; Leonidou et al., 2007; and Pla-Barber and Alegre, 2007); financial health and access to finance (Bellone et al., 2010; Matthee and Krugell, 2011; and Singh and Maiti, 2019); foreign ownership (Roberts and Tybout, 1997; and Aitken et al., 1997); spending on R&D or investment in skilled labor (Becker and Egger, 2013); productivity (Girma, et al., 2004; and Melitz, 2003); and transport costs (Albarran et al., 2013).

Linkages between energy infrastructure and exports are relatively less explored than other aspects of firms' performance. Several studies, mainly focusing on African economies, have found that an increase in power outages results in a significant decline in firms' productivity (Bbaale, 2018; and Mensah, 2016). Similarly, Iimi (2017) found that in 26 transition economies in Eastern Europe and Central Asia, eliminating power outages would substantially reduce costs for firms. Studies focusing on Africa, Eastern Europe and South Asia have documented that electricity issues, including power deficits, unserved electricity, and outages, have led to a substantial loss in output and sales (Kresic et al., 2017; Allcot et al., 2016; Carlsson et al., 2018; Diboma and Tatietse, 2013; and Zhang, 2019).

III. Power Outages and Export Orientation

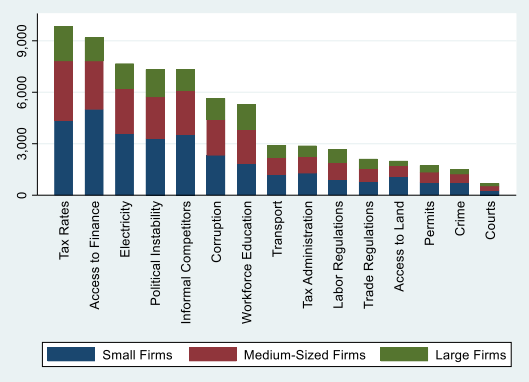
The study's main source of data is the World Bank Enterprise Survey (WBES), which is a nationally representative survey of nonagricultural and non-finance firms. Wave-II of the survey started in 2006, while in 2008-2009, the WBES started using a global methodology that makes the data completely comparable across countries. The use of a single consistent methodology based on the standardized survey instrument and sampling methodology reduces measurement error. The WBES collects data from a representative sample of the nonagricultural private economy (i.e., manufacturing and services) at the country level based on a stratified random sampling technique. The stratification is done based on firm size (small: 5-19 employees, medium: 20-99 and

large: 100 or more), the sector of the activity and geographical location.[3] The survey contains detailed quantitative and qualitative information on firms related to power outages, sales, number of workers, ownership, exports, access to finance, among others, which allows us to analyze the relationship between lack of power infrastructure and firms' export market entry decisions and performance thereafter.

The sample comprises nearly 162,000 firms across 286 country-year groups from 2006 to 2020. We cover 2012 to 2019, with the cutoff for the initial year determined by the desire to cover some major economies that have not been covered in subsequent years, including China, Bangladesh, Pakistan, and Azerbaijan. The sample used is a pure cross-section with each country and firm included only once. For countries with multiple surveys from 2012 to 2019, only the most recent survey is considered.[4] The baseline database has more than 73,214 observations in 106 countries, including 32,969 small, 25,164 medium-sized and 15,081 large firms; 41,012 firms engage in manufacturing while 32,202 provide services.

Access to electricity is the third most important obstacle faced by firms, just behind tax rates and access to finance. Nearly 11.2 percent of responding firms identified electricity as the most important obstacle they faced, nearly 2.6 times higher than firms identifying transport, the other infrastructure variable mentioned in the survey (Figure 1). The proportion is highest for small firms at 11.5 percent, followed by medium-sized (11.2 percent) and large (10.9 percent) firms.

Figure 1: Biggest Obstacles Affecting Operations



Sources: World Bank Enterprise Survey and authors' calculations.

The WBES contains information about the quality of energy infrastructure, duration and frequency of power outages, the share of electricity from generators, annual cost of electricity and loss of sales as a result of power outages. There is ample evidence that power outages are associated with lower productivity, higher costs and reduced

[3] For more details about the sampling methodology and stratification, please read the WBES document.

[4] We dropped firms that constitute more than 40 percent of country sales, firms that report average monthly power outages of more than 700 hours and countries and industries for which we did not have more than 100 observations.

sales or output (section II). We focus on power outages to evaluate the impact of power infrastructure on firms' export potential. The extent of power outages is calculated by looking at their frequency and the average duration of each outage. Power outages result in loss of sales through a variety of channels, reducing the competitiveness of firms and deterring participation in the export market. However, the extent of outages varies considerably across regions and firm size.

Figure 2a shows a clear divide among regions, with firms in Europe and Central Asia, Latin America and the Caribbean, and East Asia and Pacific experiencing an average of fewer than 14 hours of power outages a month, while firms in South Asia, Sub-Saharan Africa and the Middle East and North Africa experience on average more than 70 hours. Across most regions, small firms experience more hours of power disruptions, possibly reflecting the firms' lower ability to compensate for power outages with private alternatives such as diesel-based generation. Firms in South Asia, the Middle East and North Africa, and Sub-Saharan Africa, suffer larger losses of output due to power outages compared to those in Europe and Central Asia, Latin America and the Caribbean, and East Asia and Pacific (Figure 2b). Again, small and medium-sized firms bear the brunt as they are unable to create customized alternatives.

Figure 2a: Average Hours of Power Outage

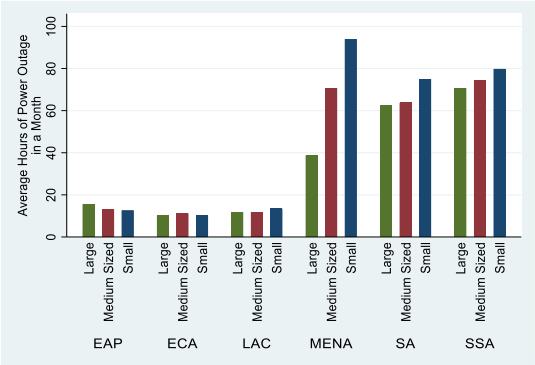
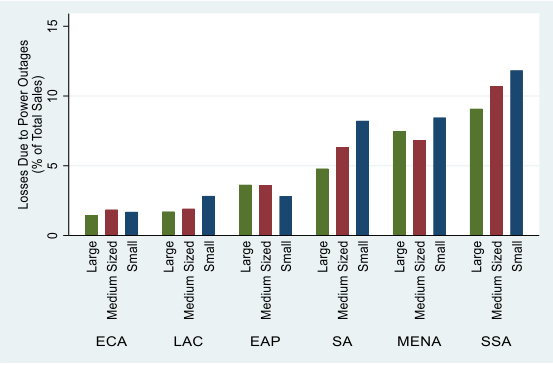


Figure 2b: Average Losses Due to Power Outage



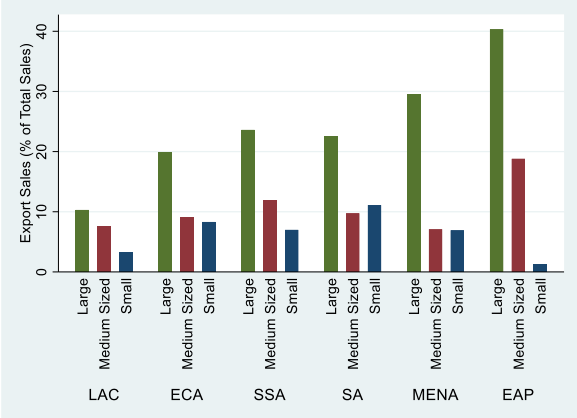
EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MENA = Middle East and North Africa, SA = South Asia, SSA = Sub-Saharan Africa.
Sources: World Bank Enterprise Survey and authors' calculations.

Some firms access electricity from private alternatives but doing so increases their cost of production and reduces their competitiveness and export orientation. A large proportion of exports are part of GVCs, and production is geographically fragmented to take advantage of varying production costs across countries and produce each component at the cheapest location. Apart from raising the cost of production, poor power infrastructure reduces competitiveness through loss of production foregone, damage to a partially completed product and costs associated with recall or disposal of faulty products.

Of the six regions we analyze, East Asia and Pacific exhibits the highest export orientation, with firms on average exporting 30.58 percent of their total sales, and has

low power outages and sales losses. Two other regions with low power outages have a much lower export orientation: Europe and Central Asia with 15.25 percent and Latin America and the Caribbean with 9.42 percent. South Asia and the Middle East and North Africa, however, exhibit a healthier export orientation despite being strongly affected by power outages. Generally, large firms have the highest export orientation across all regions, followed by medium-sized and small firms (Figure 3). The high export orientation of East Asia and Pacific is mainly driven by large and medium-sized firms, with small firms exporting less than their counterparts in other regions. Thus, the relationship between power outages and export orientation differs across regions and, therefore, warrants deeper analysis.

Figure 3: Average Export Sales (Percent of Total Sales)



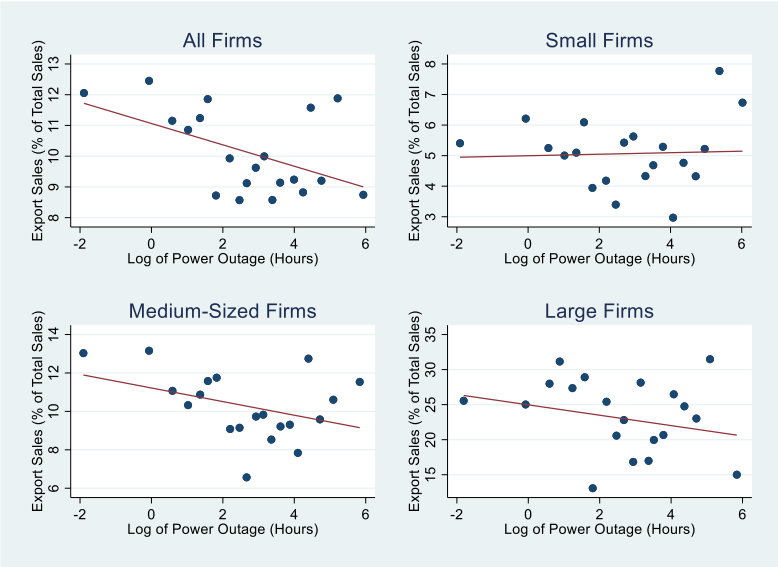
EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and the Caribbean, MENA = Middle East and North Africa, SA = South Asia, SSA = Sub-Saharan Africa.
Sources: World Bank Enterprise Survey and authors' calculations.

We find a negative relationship between the two variables when the entire sample is considered, giving credence to the premise that power outages are associated with lower export performance.[5] The negative relationship seems to be stronger for medium-sized and large firms than for the small firms, likely because medium-sized and large firms are more mechanized and, therefore, more reliant on good-quality power supply.[6]

[5] Figure 4 illustrates the binned scatterplot in which the x-axis variable is grouped into equal-sized bins and the mean of the x-axis and y-axis variables within each bin is computed. Subsequently a scatterplot is created with the population regression line.

[6] The extent of mechanization is captured by the capital–labor ratio. While medium-sized enterprises have a capital –labor ratio 7.3 times that of small industries, the ratio is 64.7 times higher for large industries.

Figure 4: Relationship between Export Orientation and Power Outages (Size)

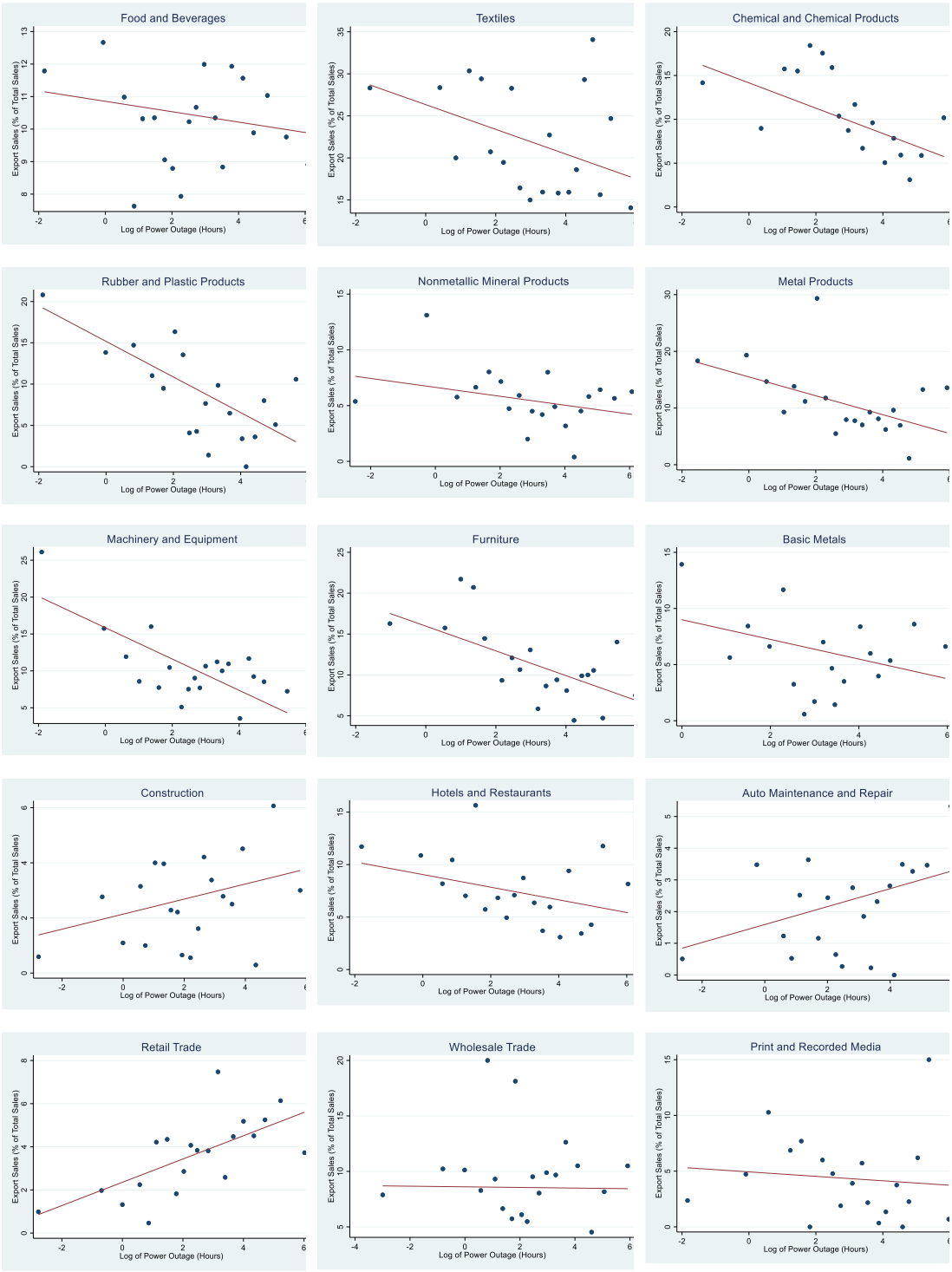


Sources: World Bank Enterprise Survey and authors' calculations.

There is a great deal of variation in the relationship between power outages and export potential across different sectors. Some industries are more vulnerable to erratic power supply than others, which will likely impact the relationship between power outages and export performance. Figure 5 highlights the relationship across the top 15 sectors accounting for nearly 82 percent of firms.[7] Across many sectors—such as textiles, chemicals and chemical products, rubber and plastic products, metal products, machinery and equipment, and furniture and basic metals—higher power outages are associated with lower export orientation. These sectors together account for nearly 60 percent of exports. Most of the sectors tend to be more mechanized and, hence, more affected by power disruptions. By contrast, selected sectors such as automobile maintenance and repair and retail trade exhibit a positive relationship, although they have a low export orientation of less than 6.0 percent of domestic sales and account for only 2.0 percent of exports. Finally, sectors such as apparel, wholesale trade and print and recorded media show no ostensible relationship. On average, the negative relationship between power outages and export performance is stronger across manufacturing than services, in line with the hypothesis that manufacturing is likely to be more dependent on infrastructure such as power and transport while services rely more on information and communication infrastructure and human capital (Eichengreen and Gupta, 2011; and Noland et al., 2013).

[7] The sectors are classified according to the International Standard Industrial Classification (ISIC) Rev 3.1.

Figure 5: Power Outages and Export Potential across Major Sectors



Sources: World Bank Enterprise Survey and authors' calculations.

However, a number of firm-specific factors have been found in the literature to impact export performance (section II). In the following section, we evaluate the impact of power outages on firms' export performance, controlling for many of these factors using a regression analysis framework.

IV. Empirical Evidence

A. Data and Empirical Methodology

The various nominal variables in the data set such as sales and values of various inputs like capital, material and energy are originally measured in local currency. To convert them into constant United States (US) dollar terms, we deflate them using the consumer price index (CPI) and use the bilateral exchange rate.[8] Data on CPI and exchange rate were culled from the online World Development Indicator.

The literature has identified several firm-, industry- and country-specific attributes that influence firms' decisions to export and export propensity. Firms' *productivity* has been identified as one of the most important and commonly used predictors of export performance. The literature suggests that export market entry is marred by sunk cost, and only the most productive firms self-select into the market (Bernard and Wagner, 1997; Roberts and Tybout, 1997; Bernard and Jensen, 1999; Bernard et al., 2003; and Melitz, 2003) and they are capable of covering the variable and fixed trade costs of entry (Hiep and Nishijima, 2009). Bernard et al. (2003) observed that different potential destination markets have different conditions, hence, the level of productivity needed to enter a particular market varies with each market. Productive firms can enter many markets, thus their export share is larger (Helpman et al., 2008; and Yoshino, 2008). Melitz (2003) suggested that firms' productivity is directly linked with intensive export margin. However, Farinas and Martin-Marcos (2007) observed that the effect of labor productivity on export propensity among Spanish firms is ambiguous; different effects are observed in different industries. In contrast, for a sample of firms from Chile, Alvarez (2007) found the effect of productivity on export propensity to be positive and significant. Hence, it is expected that productivity will have a positive relationship with firms' export entry decision, but productivity's effect on firms' post-entry export propensity is not clear.

Another factor that has been found to influence firms' export decisions and propensity is firm *size.* Numerous studies have suggested that firm size and exporting are positively related (Chetty and Hamilton, 1993; Sterlacchini, 2001; and Kumarasamy and Singh, 2018). Pla-Barber and Alegre (2007), however, refuted the significance of the relationship, and Hiep and Nishijima (2009) found mixed results. Thus, there exists some ambiguity on the direction of the relationship between a firm's size and export performance. Similarly, *age* is another firm-specific attribute related to export performance (Roberts and Tybout, 1997). Majocchi et al. (2005) found that older firms are more export intensive as they tend to be more efficient.[9] In contrast, Alvarez and López (2005) suggested that, with age, the likelihood of firms' exporting declines, and Fryges (2006) observed that newer firms have higher export volume. Ottaviano and

[8] We considered the wholesale price index as the price deflator when we did not find the CPI information for a particular country.

[9] The literature suggests that inefficient firms either do not survive or tend to exit the markets.

Martincus (2011), however, found that a firm's age and exporting probability are statistically not correlated.

With the development of "new" new trade theory, firms' *access to finance* has become critical to their propensity to export (Muûls, 2008; Manova, 2011; and Wagner, 2014). Studies have shown that financial constraint is detrimental to exports' extensive margin (Muûls, 2008; Minetti and Zhu, 2011; Singh and Maiti, 2019; and Kumarasamy and Singh, 2018) and intensive margin (Berman and Hericourt, 2010; Arndt et al., 2012; and Secchi, et al., 2011). It has been argued that access to finance reduces firms' productivity threshold to self-select into the export market. Thus, we expect firms' access to finance and export performance to be positively related.

Among the determinants of firms' export performance, the role of *foreign ownership* has been strongly emphasized. Foreign ownership helps firms self-select into the export market by lowering the productivity threshold (Boddin, et al., 2017). Foreign ownership increases firms' export probability by alleviating market failure. Foreign-owned firms are expected to have a better intensive margin (Manova and Zhang, 2009). Foreign-owned firms tend to have better access to market-search information. They have stronger business relationships, therefore, and can take advantage of parent organization networks, which facilitate the foreign-owned firms' exporting activities. Thus, a positive relationship is expected between foreign ownership and firms' export performance.

The literature identifies R&D, foreign technology and use of foreign inputs as influencing self-selection into the export market and performance post-entry into the export market. Several studies have found a positive relationship between R&D and firms' export margin (Greenhalgh, 1990; Buxton et al., 1991; Willmore, 1992; and Bernard and Wagner, 1998). Similarly, Dasgupta and Siddharthan (1985), Lall (1986) and Kumar and Siddharthan (1994) emphasized the role of foreign input in firms' export performance. Use of foreign technology improves the capability of the firm and its human resources, which increases its productivity and efficiency, which, in turn, help the firm self-select into the export market and sustain performance post-entry (Yang et al., 2004).

To summarize, firms' productivity, size, age, foreign ownership, access to finance, foreign technology, foreign input, and R&D are some of the variables found in the literature that influence exporting decision and performance.

We evaluate the role of power infrastructure in impacting exporting decision and propensity, controlling for these factors. The study examines the effect of power outages on firms' extensive margin (exporting decision) and intensive margin (exports as share of sales). The inclination to export is an unobserved latent variable but whether a firm is exporting or not can be observed. We model the unobserved variable as an unobserved function involving *power outage* as the principal predictor variable along with other control variables using a probit estimation. We specify the probability that the firm will export as follows:

$$Pr(export\_decision = 1) = \emptyset(\alpha_0 + \beta_1 power\_outage + \beta_2 age + \beta_3 size + \beta_4 productivity + \beta_5 foreign + \beta_6 finance + +\beta_7 R\&D + \varepsilon) \quad (1)$$

where the *export_decision* variable takes two unique values, 0 and 1, with 0 denoting that the firm does not participate in the export market and 1 indicating the firm's presence in the export market. ∅ is standard cumulative normal distribution while *power_outage* is our main variable of interest, taking a value of 1 if the firm faces a problem of power outage and 0 otherwise.[10] The baseline model for export propensity is outlined below.

$$export\_propensity = \alpha_0 + \beta_1 power\_outage + \beta_2 age + \beta_3 size + \beta_4 productivity + \beta_5 foreign + \beta_6 finance + +\beta_7 R\&D + \varepsilon \quad (2)$$

where *export propensity* is the share of direct and indirect export sales in overall sales.

Across both estimations, we control for a number of other variables found in the literature to influence export decision: (1) *age*, which indicates the log of the age of the firm; (2) the vector *foreign,* which covers foreign resources employed in the firm, including foreign ownership, foreign input and foreign technology; (3) *size* of the firm, depending on the number of people employed in the firm; (4) *finance,* reflecting the firm's access to formal lines of credit or loans from financial institutions; (5) firm's investing in *R&D;* and (6) *productivity*. The foreign, finance and R&D variables are in the form of a dummy variable taking the value 1 if the firm uses foreign resources, can access finance from a formal source and undertakes R&D. The vector *size* includes a dummy for medium-sized and large firms.

Finally, *productivity* captures the firm's productivity based on alternate specifications, which are elaborated below. Barring the productivity variable, all others are directly computed from the WBES data set. For the productivity variable, we first focus on a relatively crude measure of labor productivity, calculated as sales per worker. Then we introduce a more robust measure involving a regression-based method to calculate total factor productivity (TFP). The calculation of TFP involves using a Cobb-Douglas production function with different factors of production across various specifications. The first specification includes only capital and labor as the factor of production, while the second specification also includes intermediate goods. In the final specification, we also include energy and fuel as factors of production.

[10] While we used loss of sales resulting from power outages in the analysis in section III, we dropped it for the empirical analysis because of the possibility of multicollinearity with the productivity variable.

To estimate TFP, the aggregate output of the firm is measured as its total sales, while the value of capital is captured using the replacement value of machinery, vehicles, and equipment. To assess the value of labor, we use total compensation paid to workers, comprising wages, salaries, and bonuses. Intermediate goods are determined by the cost of raw materials and intermediate materials, and energy and fuel are measured using the cost of fuel and energy. TFP in every specification is estimated as the residual of the production function. The cross-section production function takes the following form:

$$Q_i = AK_iL_i\varepsilon^{v_i} \tag{3}$$

After taking a log and transforming (2), we get

$$lnQ_i = lnA + \beta_1 lnK_i + \beta_2 lnL_i + v_i \tag{4}$$

where, β_i is the measure of factor elasticity and A is the measure of productivity (TFP). Although it is ideal to estimate the production function for each country-industry pair, owing to the data limitation—the limited number of country-industry observations for estimation—we have estimated the production function for each country separately. To ensure comparability across countries, the nominal values are converted to constant US dollars (the base year is 2010) by using the CPI and bilateral exchange rates. While TFP is a more conventional measure of productivity, it can be calculated only for a small sub-sample, given the many missing observations for various input measures in the Cobb-Douglas specification.

B. Key Results

In the various regression specifications to circumvent the issues associated with idiosyncratic risks associated with country, industry, and year, we have included country, year, and industry fixed-effects in the model. The country fixed-effect soaks up the country characteristics that might affect firms' export decision and performance, while the sector fixed-effect captures differences in relative prices and other differences that may result from the differential impact of sector-specific characteristics such as differing factor prices, demand conditions, export market orientation, among others. Finally, the year fixed-effect absorbs the variation in export decision and performance arising because of the global economic environment in a particular year.

A key issue to be considered while investigating the impact on export performance is the possibility of a bidirectional relationship with other variables. Related to our main variable of interest, the bidirectional relationship entails the possibility of the presence of endogeneity between the decision to export and power outages. While power outages may undermine firms' export performance, it is also possible that better-quality power is served where exporting firms are concentrated, such as export processing or special economic zones. The literature does not indicate endogeneity between power outages and firms' decision to enter the export market. To rule out the existence of endogeneity between power outages and firms' export decision, however, we run an instrument variable probit model with the mean of power outages at the country-industry level as instruments. We find that the Wald test of exogeneity is not rejected, thereby validating our hypothesis of absence of endogeneity between power outages

and firms' export decision. Given that the mean of power outages at the country-industry level is less heterogeneous, we created another variable, viz. the mean of power outages at the country-city-industry level, and re-estimated the instrument variable probit model. The Wald test of exogeneity again corroborates the absence of endogeneity between firms' export decision and power outages.

The literature, however, points to some of the other explanatory variables having a bidirectional relationship. One such variable is access to finance. While the channels through which *access to finance* can influence the decision to export have been elaborated, there exist channels by which the decision to export can also influence a firm's access to finance. Kumarasamy and Singh (2018) pointed out that firms with access to finance find it easier to enter the export market and that exporting firms are better able to access finance. Exporting firms may be signaling financial institutions that they have a competitive advantage over their competitors (non-exporters) and, hence, are more creditworthy, which increases their chance of getting credit (see Campa and Shaver [2002] and Muûls [2008]).

To overcome the problem of endogeneity, we employ an instrument variable probit model (IV probit). We use the information on whether a firm's accounts are audited or not as the instrument of access to finance. A firm with an audited account is likely to have access to formal finance as the audited account release provides information about the firm's performance and governance. Such information helps lenders weigh a firm's investment prospects and repayment capabilities, but is likely to be uncorrelated with the firm's export decision.

The results of the IV probit model are in Table 1.[11] Firms' characteristics such as size, age, foreign ownership, foreign technology, and R&D remain important predictors of exporting decision. Access to finance, foreign inputs and productivity remain important determinants of export decision but their marginal effects are smaller than those of size, age, and other variables.[12]

[11]The standard diagnostic tests indicate that firms' access to finance and exporting decision are endogenous, and the instrument variable used in the model satisfies the statistical properties in terms of under-identification and weak instrument.

[12] One difference is that out of the four productivity measures only two—labor productivity and TFP measured using labor, capital, material, and energy—are now significant.

Table 1. Power Outages and Firms' Export Decision (IV Probit Estimation)

	Dependent Variable: Firms' Export Decision (Dummy)							
	Specification I		Specification II		Specification III		Specification IV	
	Baseline	Marginal	Baseline	Marginal	Baseline	Marginal	Baseline	Marginal
Log Age	0.075***	0.130***	0.043**	0.073**	0.048**	0.077**	0.052**	0.082**
	(0.018)	(0.019)	(0.021)	(0.026)	(0.022)	(0.027)	(0.022)	(0.026)
Foreign Input	0.004***	0.006***	0.003***	0.004***	0.003***	0.004***	0.003***	0.004***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Power Outage	-0.069**	-0.096***	-0.054**	-0.132***	-0.049*	-0.133***	-0.045*	-0.134***
	(0.024)	(0.024)	(0.026)	(0.024)	(0.027)	(0.024)	(0.027)	(0.024)
Size (Medium)	0.305***	0.397***	0.217***	0.272***	0.243***	0.288***	0.253***	0.295***
	(0.059)	(0.043)	(0.069)	(0.064)	(0.07)	(0.063)	(0.071)	(0.063)
Size (Large)	0.713***	0.959***	0.563***	0.733***	0.619***	0.767***	0.651***	0.789***
	(0.124)	(0.076)	(0.146)	(0.119)	(0.149)	(0.118)	(0.151)	(0.116)
Foreign Firm	0.680***	0.629***	0.619***	0.670***	0.632***	0.674***	0.640***	0.677***
	(0.038)	(0.06)	(0.058)	(0.042)	(0.058)	(0.042)	(0.057)	(0.042)
Use of Foreign Technology	0.144***	0.159***	0.175***	0.205***	0.190***	0.211***	0.191***	0.210***
	(0.031)	(0.026)	(0.041)	(0.034)	(0.041)	(0.034)	(0.042)	(0.034)
Dummy for R&D	0.207***	0.375***	0.107*	0.278***	0.123**	0.291***	0.140**	0.306***
	(0.049)	(0.046)	(0.059)	(0.073)	(0.062)	(0.075)	(0.063)	(0.074)
Access to Finance	1.146***	0.050	1.584***	1.046***	1.520***	0.999***	1.469***	0.947**
	(0.289)	(0.474)	(0.227)	(0.279)	(0.241)	(0.283)	(0.255)	(0.29)
Productivity (Log Sales per Worker)	0.037***	0.049*						
	(0.015)	(0.021)						
Productivity (KL)			0.013	0.01				
			(0.014)	(0.013)				
Productivity (KLM)					0.017	0.011		
					(0.015	(0.014)		
Productivity (KLME)							0.034**	0.032*
							(0.016	(0.015)
Constant	-2.177***		-1.576***		-1.619***		-1.660***	
	(0.22)		(0.145)		(0.141)		(0.138)	
Observation	21643		14237		13704		13549	
Wald-chi^2	6930.44		7135.92		6417.17		5981.68	
Wald test of exogeneity	8.13***		17.67***		15.50***		13.54***	
Under identification test:								
Kleibergen–Paaprk LM statistic	72.460***		53.727***		55.355***		55.924***	
Weak identification test:								
Kleibergen–Paaprk Wald F statistic	72.616***		53.733***		55.380***		55.962***	

Productivity (KL) = productivity based on capital and labor, Productivity (KLM) = productivity based on capital, labor and material, Productivity (KLME) = productivity based on capital, labor material and energy, LM = Langrange Multiplier, R&D = research and development.

Note: *, ** and *** represent significance at 10, five and one percent level of significance. Country, year, and industry fixed-effects are included in all the specifications.

Sources: Authors' calculations based on World Bank Enterprise Survey data.

Our main variable of interest, i.e., power outages, is shown to have a significant negative impact on the decision to export. The marginal effect of the estimation indicates that firms facing power outages have nine to 13 percent lower chances of getting into the export market because of a couple of factors:

(1) A major share of exports forms part of GVCs, whereby the production process is geographically fragmented to take advantage of varying production costs across countries, allowing firms to produce each component at the cheapest location. Power outages dent the competitiveness of firms by forcing them to rely on costlier alternatives such as diesel generators.
(2) Power outages can lead to the production of faulty intermediate products, hampering the quality of the final product and inflicting losses that may be disproportionate to the share of the value of the product in the production chain.

Older firms are found to have a higher likelihood of entering the export market, in line with Roberts and Tybout (1997) and Majocchi et al. (2005), who suggested that with age, firms become more efficient and able to self-select to enter the export market. Similarly, larger firms were found to have a greater chance of entering the export market. The likelihood of a large firm entering the export market is 70-90 percent higher than that of a small one, whereas a medium-sized firm has a 28-39 percent greater chance. Thus, medium-sized and large firms are able to self-select into the export market, most likely on account of higher efficiency, access to information, networking, economies of scale and managerial capabilities.

Similarly, foreign ownership is found to have a positive association with the decision to enter the export market. The marginal effect suggests that foreign-owned firms have a 17 percent higher likelihood of entering the export market than domestically owned firms. The use of foreign input and foreign technology is positively associated with the decision to enter the export market. The different measures of productivity are found to be positively correlated with the decision to enter the export market. Another variable found to raise the likelihood of a firm entering the export market is productivity. Across all the different measures of productivity, the impact is found to be positive and significant. Finally, access to finance is found to have a positive effect on firms' exporting decision.[13]

Given that our endogenous variable is binary, and the instrument variable probit model is not designed for the binary endogenous variable, we make use of the conditional (recursive) mixed process estimator (CMP) to validate the IV probit results and estimate the model with the binary endogenous variable to evaluate the robustness analysis of the earlier results. The CMP model allows us to incorporate country, year, and industry fixed-effects with ease while estimating marginal effect. The results are outlined in Table 2a. For brevity, we report the marginal effect results only, which

[13] We tested the relevancy of fixed-effect using the t-test. Results suggest that there exists difference among countries in terms of exporting. Further, there exists a statistically significant year and industry effect in firms' export decision. This suggests that the effect of the control variables in the line of existing literature.

indicate that power outages remain an important predictor of firms' export decision, in addition to other variables identified in the literature. The impact of power outages is consistent across different specifications.

Table 2a. Power Outages and Firms' Export Decision (IV Probit with Conditional Mixed Process Estimator)

	Dependent Variable: Firms' Export Decision (Dummy)			
	Specification I	Specification II	Specification III	Specification IV
Log Age	0.010***	0.008**	0.008**	0.009**
	(0.003)	(0.004)	(0.004)	(0.004)
Size (Medium)	0.042***	0.040***	0.042***	0.040***
	(0.006)	(0.007)	(0.007)	(0.007)
Size (Large)	0.098***	0.109***	0.113***	0.112***
	(0.007)	(0.008)	(0.008)	(0.008)
Foreign Input	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Power Outage	-0.021***	-0.015**	-0.015**	-0.013**
	(0.005)	(0.006)	(0.006)	(0.006)
Foreign Firm	0.150***	0.142***	0.142***	0.141***
	(0.008)	(0.009)	(0.010)	(0.010)
Use of Foreign Technology	0.024***	0.037***	0.039***	0.038***
	(0.006)	(0.008)	(0.008)	(0.008)
Dummy for R&D	0.021**	0.015**	0.015**	0.015**
	(0.005)	(0.007)	(0.007)	(0.007)
Access to Finance	0.437***	0.435***	0.435***	0.435***
	(0.003)	(0.004)	(0.004)	(0.004)
Productivity (Log Sales Per Worker)	0.000			
	(0.002)			
Productivity (KL)		0.000		
		(0.002)		
Productivity (KLM)			0.001	
			(0.003)	
Productivity (KLME)				0.004
				(0.003)
Observation	21643	14281	13753	13598

Productivity (KL) = productivity based on capital and labor, Productivity (KLM) = productivity based on capital, labor and material, Productivity (KLME) = productivity based on capital, labor material and energy, R&D = research and development.

Note: *, ** and *** represent significance at 10, five and one percent level of significance. Country, year and industry fixed-effect included in all the models. Marginal effect is also calculated for the same equation.

Sources: Authors' calculations based on World Bank Enterprise Survey data.

Across both estimations in Tables 1 and 2a, large and medium-sized firms were observed to have a greater probability of entering the export market. However, power outages could influence the size of the firm. Reducing power outages, by improving the competitiveness of firms, makes them more amenable to expand and reap the benefits of economies of scale, thereby influencing the decision to enter the export market. To correct for potential bias, we re-estimate the model outlined in Table 2a by dropping the size dummies. Again, we have reported only the marginal effect to conserve space. The results outlined in Table 2b are broadly similar to those in Table

2a, with minor differences. The impact of power outages on the decision to enter the export market becomes slightly more prominent. The alternate measures of productivity are now positively associated with the decision to enter the export market.[14]

Table 2b. Power Outages and Firms' Export Decision (IV Probit with Conditional Mixed Process Estimator) without Size Dummies

	Dependent Variable: Firms' Export Decision (Dummy)			
	Specification I	Specification II	Specification III	Specification IV
Log Age	0.023***	0.020***	0.022***	0.022***
	0.004	0.004	0.005	0.004
Foreign Input	0.001***	0.001***	0.001***	0.001***
	0.000	0.000	0.000	0.000
Power Outage	-0.023***	-0.017***	-0.016**	-0.015**
	0.005	0.006	0.007	0.006
Foreign Firm	0.180***	0.172***	0.173***	0.172***
	0.008	0.010	0.011	0.010
Use of Foreign Technology	0.041***	0.058***	0.061***	0.060***
	0.006	0.008	0.009	0.008
Dummy for R&D	0.037***	0.031***	0.031***	0.031***
	0.006	0.007	0.008	0.007
Access to Finance	0.435***	0.436***	0.436***	0.436***
	0.003	0.004	0.004	0.004
Productivity (Log Sales per Worker)	0.003***			
	0.002*			
Productivity (KL)		0.004*		
		0.003		
Productivity (KLM)			0.006*	
			0.003	
Productivity (KLME)				0.009***
				0.003
Observation	21798	14346	13807	13650

Productivity (KL) = productivity based on capital and labor, Productivity (KLM) = productivity based on capital, labor and material, Productivity (KLME) = productivity based on capital, labor material and energy, R&D = research and development.

Note: *, ** and *** represent significance at 10, five and one percent level of significance. Country, year, and industry fixed-effect included in all the models. Marginal effect is also calculated for the same equation.

Sources: Authors' calculations based on World Bank Enterprise Survey data.

Having evaluated the impact of power outages on export decision, we assess the impact power outages have on export propensity. Export propensity is calculated as the share of direct and indirect export sales as a percentage of total sales once the firms have entered the export market. Since export propensity will lie in the range of 0

[14] Another way of correcting for potential bias is to check for possible presence of endogeneity. We instrument the firm's present size with the firm's size three years ago. A firm with more workers in the past is likely to remain or evolve into a medium-sized or large firm. However, the size of the firm in the past is unlikely to be correlated with the firm's export decision. The results are in Annex Table A1, where we find that even after accounting for endogeneity, power outages exert a statistically significant impact on the decision to enter the export market.

to 100, we use Tobit estimation to evaluate the relationship between export propensity and power outages. The specification is outlined in Equation 2. The other control variables remain the same as in the case of exporting decision. The results are outlined in Table 3.

Table 3. Power Outages and Firms' Export Propensity (Tobit Estimation)

	Dependent Variable: Firms' Export Propensity (Export Sales as a Percentage of Total Sales)			
	Specification I	Specification II	Specification III	Specification IV
Log Age	0.051	-0.637	-0.525	-0.375
	(1.008)	(1.253)	(1.276)	(1.290)
Foreign Input	0.336***	0.334***	0.318***	0.324***
	(0.022)	(0.027)	(0.027)	(0.028)
Power Outage	-4.394**	-4.615**	-4.328*	-4.374*
	(1.416)	(1.776)	(1.796)	(1.821)
Size (Medium)	30.048***	31.609***	31.664***	31.561***
	(1.799)	(2.236)	(2.266)	(2.293)
Size (Large)	64.589***	70.610***	70.996***	71.272***
	(1.956)	(2.474)	(2.507)	(2.535)
Foreign Firm	38.857***	37.840***	37.786***	38.378***
	(1.902)	(2.288)	(2.324)	(2.357)
Use of Foreign Technology	9.016***	13.407***	13.640***	13.491***
	(1.627)	(2.015)	(2.044)	(2.073)
Dummy for R&D	15.367***	16.149***	16.393***	16.671***
	(1.452)	(1.828)	(1.848)	(1.872)
Access to Finance	6.355***	6.931***	6.563***	7.042***
	(1.372)	(1.721)	(1.748)	(1.766)
Productivity (Log Sales per Worker)	3.649***			
	(0.483)			
Productivity (KL)		2.909***		
		(0.665)		
Productivity (KLM)			3.250***	
			(0.790)	
Productivity (KLME)				3.913***
				(0.825)
Constant	-135.250***	-97.193***	-95.906***	-97.214***
	(6.277)	(4.845)	(4.929)	(4.991)
Pseudo-R^2	0.082	0.089	0.090	0.090
Observation	21799	14350	13819	13662
Country Fixed-Effect	Yes	Yes	Yes	Yes
Industry Fixed-Effect	Yes	Yes	Yes	Yes
Year Fixed-Effect	Yes	Yes	Yes	Yes

Productivity (KL) = productivity based on capital and labor, Productivity (KLM) = productivity based on capital, labor and material, Productivity (KLME) = productivity based on capital, labor material and energy, R&D = research and development.

Note: *, ** and *** represent significance at 10, 5 and 1 percent level of significance. Country, year, and industry fixed-effect included in all the models.

Sources: Authors' calculations based on World Bank Enterprise Survey data.

We find that power outages emerge as a significant predictor of export propensity. Firms facing power outages have significantly lower export propensity than firms that do not face outages. Thus, power outages not only dissuade firms from entering the export market but also negatively impact their export propensity after they enter the

market. Power outages—by increasing the cost of production because of reliance on more expensive alternate sources of power, thus disrupting the assembly line and delaying production and creating products that may not be up to international standards—are likely to hurt export margins of firms and reduce their export propensity. These factors become even more important in GVCs, which are dependent on timely production of various parts and components of international standard at a reasonable cost.

Among other variables, firms' age is not related to export propensity. Firms using foreign input, however, exhibit higher export propensity. Using a foreign input can help a firm improve its competitiveness by reducing input costs, which could also reflect a firm's participation in GVCs where firms use imported inputs to produce for external demand. Similarly, foreign ownership is associated with better export propensity, especially if it takes the form of efficiency-seeking foreign direct investment. Foreign ownership facilitates GVC participation through internationalization of local firms by helping them (1) access global markets, supply, and distribution networks; (2) ensure that local sourcing of intermediate products meets international standards; and (3) enhance scale and productivity.

Next, we aim to account for the fact that most firms in our sample are non-exporters and that there is a strong clustering of firms at zero export value,[15] which is likely to result in biasedness in the estimated coefficient and the problem of selection biasedness. The process of exporting involves two stages: (1) deciding to export and (2) deciding how much to export (volume of export). The Tobit model has a limitation in dealing with the simultaneity and clustering at zero. To handle the inadequacies in the Tobit model and its effect on estimated coefficients, we use the Heckman selection model (Heckman, 1976), which helps deal with the selection and truncation problem in a single framework. Heckman selection models assume that there is an underlying regression relationship:

$$Export\_share_j^* = X_j\beta + u_{1j} \text{ (export share equation)} \quad (3)$$

The dependent variable ($Export\_share$) is not always observed. The dependent variable is only observed for a particular observation j if

$$z_j\gamma + u_{2j} > 0 \text{ (export decision equation)} \quad (4)$$

where,

$$u_1 \sim N(0, \sigma)$$

$$u_2 \sim N(0,1)$$

$$corr(u_1, u_2) = \rho$$

If $\rho \neq 0$, the Heckman selection model is appropriate to use.

[15] In our original sample of more than 70,000 firms, nearly 76.0 percent do not engage in any kind of export activity.

Table 4a. Power Outages and Firms' Export Propensity (Heckman Selection Estimation)

	Dependent Variable: Firms' Export Propensity (Export Sales as a Percentage of Total Sales)			
	Specification I	Specification II	Specification III	Specification IV
Log Age	-3.164***	-2.480***	-2.505***	-2.323***
	(0.762)	(0.872)	(0.873)	(0.872)
Foreign Input	0.120***	0.109***	0.102***	0.100***
	(0.021)	(0.023)	(0.023)	(0.023)
Power Outage	-2.993***	-3.039***	-3.181***	-3.371***
	(0.966)	(1.135)	(1.138)	(1.136)
Size (Medium)	10.604***	8.829***	7.995***	7.289***
	(2.019)	(2.254)	(2.276)	(2.277)
Size (Large)	23.922***	22.883***	21.281***	20.157***
	(3.348)	(3.689)	(3.707)	(3.721)
Foreign Firm	18.550***	16.727***	16.093***	15.869***
	(2.058)	(2.189)	(2.162)	(2.162)
Dummy for R&D	4.590***	5.059***	4.632***	4.203***
	(1.318)	(1.448)	(1.450)	(1.460)
Use of Foreign Technology	3.438***	4.064***	3.852***	3.573***
	(1.153)	(1.399)	(1.398)	(1.395)
Access to Finance	0.106	0.155	-0.326	-0.315
	(1.106)	(1.278)	(1.264)	(1.272)
Productivity (Log Sales per Worker)	0.956**			
	(0.391)			
Productivity (KL)		1.396***		
		(0.451)		
Productivity (KLM)			1.665***	
			(0.515)	
Productivity (KLME)				1.568***
				(0.532)
Constant	-12.529	1.743	7.024	9.380
	(12.496)	(9.761)	(9.647)	(9.713)
Mills lambda	31.964***	29.305***	26.969***	25.497***
	(4.699)	(4.708)	(4.650)	(4.679)
Observation	19525	13013	12542	12407
Wald-chi^2	1771.59***	1433.33***	1420.52***	1430.22***
Rho	0.832	0.802	0.761	0.732
Sigma	38.422	36.536	35.449	34.892

Productivity (KL) = productivity based on capital and labor, Productivity (KLM) = productivity based on capital, labor and material, Productivity (KLME) = productivity based on capital, labor material and energy, R&D = research and development.
Note: *, ** and *** represent significance at 10, five and one percent level of significance. Country, year, and industry fixed-effect included in all the models.
Sources: Authors' calculations based on World Bank Enterprise Survey data.

Table 4a reports the results of the Heckman selection model. Across all the specifications of the model, the value of *rho* is not equal to zero ($\rho \neq 0$), thereby justifying the use of the Heckman model. Table 4a shows that the conclusions from the Heckman selection model are broadly in line with Tobit results. Power outages remain a major driver of export propensity across all specifications, with the impact being significant at 1.0 percent level of significance.

There are some differences between the Heckman selection and the Tobit estimation. Under the Tobit estimation, younger firms exhibit higher export propensity while access to finance no longer has a positive association with export propensity. The relationship between export propensity and the rest of the variables is in tandem with the Tobit model and consistent with the literature.

Table 4b. Power Outages and Firms' Export Propensity (Heckman Selection Estimation) without Size Dummies

	Dependent Variable: Firms' Export Propensity (Export Sales as a Percentage of Total Sales)			
	Specification I	Specification II	Specification III	Specification IV
Log Age	-0.857	-0.069	-0.186	-0.148
	(0.952)	(1.063)	(1.076)	(1.076)
Foreign Input	0.137***	0.136***	0.130***	0.126***
	(0.025)	(0.028)	(0.028)	(0.028)
Power Outage	-3.224***	-3.336**	-3.525**	-3.694***
	(0.961)	(1.135)	(1.144)	(1.141)
Foreign Firm	21.856***	20.384***	19.850***	19.295***
	(2.748)	(2.963)	(2.983)	(2.982)
Dummy for R&D	6.048***	6.699***	6.341***	5.744***
	(1.603)	(1.749)	(1.776)	(1.788)
Use of Foreign Technology	5.914***	6.952***	6.665***	6.165***
	(1.397)	(1.782)	(1.803)	(1.797)
Access to Finance	2.083	2.255	1.771	1.620
	(1.350)	(1.562)	(1.554)	(1.570)
Productivity (Log Sales per Worker)	1.200***			
	(0.450)			
Productivity (KL)		1.925***		
		(0.505)		
Productivity (KLM)			2.271***	
			(0.564)	
Productivity (KLME)				2.020***
				(0.579)
Constant	-2.501***	-1.520***	-1.509***	-1.518***
	(0.099)	(0.079)	(0.080)	(0.081)
Mills lambda	29.283***	27.815***	26.261***	24.479***
	(5.242)	(5.449)	(5.482)	(5.496)
Observation	19525	13013	12542	12407
Wald-chi^2	1822.55***	1443.32***	1416.48***	1433.08***
Rho	0.78	0.76	0.74	0.70
Sigma	37.45	36.22	35.48	34.72

Productivity (KL) = productivity based on capital and labor, Productivity (KLM) = productivity based on capital, labor and material, Productivity (KLME) = productivity based on capital, labor material and energy, R&D = research and development.

Note: *, ** and *** represent significance at 10, five and one percent level of significance. Country, year, and industry fixed-effect included in all the models.

Sources: Authors' calculations based on World Bank Enterprise Survey data.

To account for the potential biasedness in the estimation because of the inclusion of size dummies, we rerun our estimation first by dropping the size dummies. The results are in Table 4b and are similar to the baseline results highlighted in Table 4a. We find

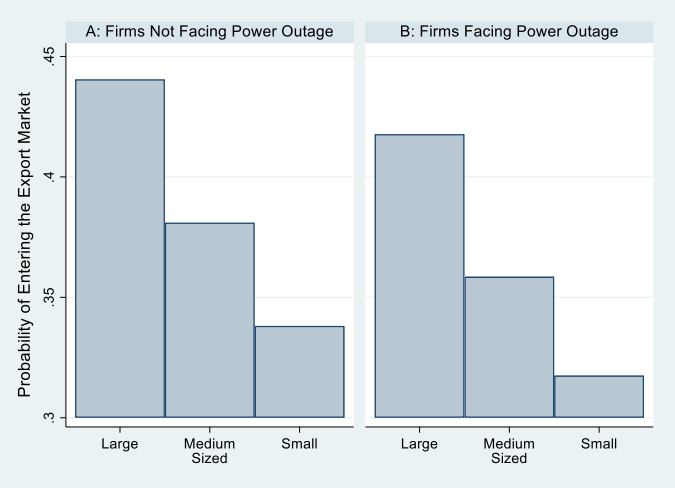
that power outages exert a slightly bigger impact on export propensity when size dummies are not considered.[16]

Thus, power outages continue to have a strong and significant negative impact on export propensity across all the specifications, thereby buttressing our claim that that power outages are not only a serious concern for firms looking to enter the export market but also a hindrance to firms' post-entry export propensity.

C. Differential Impact across Firm Size

An advantage of using a database such as the WBES is its ability to allow us to study how the impact of power outages on export decision and export propensity varies according to firm size. The advantage becomes important as data from the WBES indicate that lack of electricity is a bigger problem for small firms than for medium-sized and large firms, possibly because small firms lack the resources to arrange for customized alternatives such as captive generators (Figure 1). At the same time, the negative relationship between power outages and export performance is somewhat stronger for medium-sized and large firms than for small firms, likely because the medium-sized and large firms tend to be more mechanized and, therefore, more reliant on the good-quality power supply (Figure 4). Several factors apart from power outages impact the decision to export and export propensity. It is important, therefore, to delve deeper into the differential impact of power outages across firms of varying sizes.

Figure 6: Export Market Entry Decision by Firm Size and Power Quality

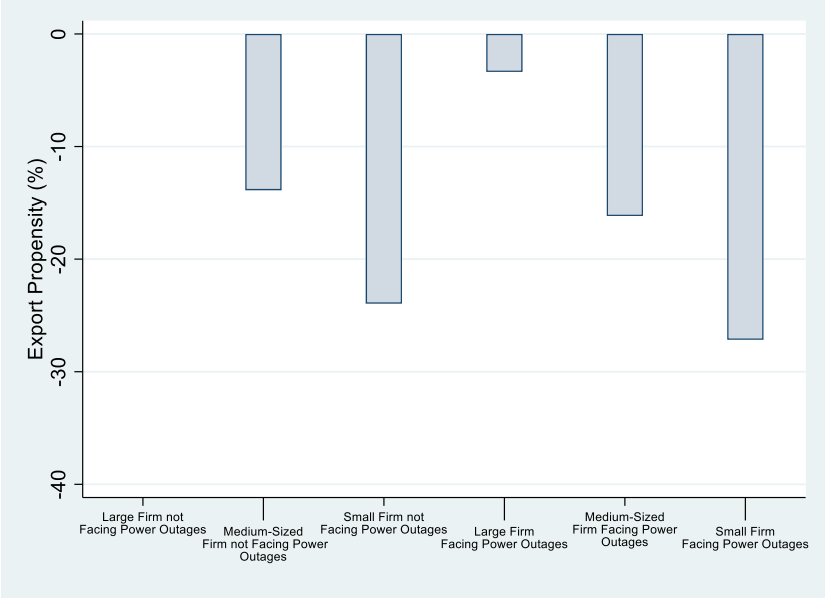


Sources: World Bank Enterprise Survey and authors' calculations.

[16] To control for the potential endogeneity between firm size and export propensity, we also estimate the Heckman model after instrumenting the firm's present size with the firm's size three years back. The results, highlighted in Table A2, are similar to those in Table 4a, thereby revalidating our hypothesis that quality of power plays a vital role in firms' export propensity. The relationship between export propensity and other variables is in line with Table 4a and 4b indicating the robustness of the estimated results.

First, we evaluate how power outages affect the decision to enter the export market across different firm sizes. We use the common mixed process estimation and Heckman selection mode similar to the one used in Table 3 but add an interaction term for power outages and firm size. We estimate that the marginal effects and varying impact of power outages are highlighted by the coefficient of the interaction term. Figure 6 outlines the results for different firm sizes. Panel A outlines the probability of entering the export market for firms that do not suffer power outages, while Panel B outlines the probability for firms experiencing power outages. Large firms have the highest probability of entering the export market, followed by medium-sized and small firms, regardless of power outages. We find that across all firm sizes, firms experiencing power outages are three to four percentage points less likely to enter the export market than firms not impacted by power outages.[17]

Figure 7: Export Propensity by Firm Size and Power Quality



Sources: World Bank Enterprise Survey and authors' calculations.

Next, we evaluate the impact of power outages on export propensity of firms of different sizes. Based on regression results and the literature, it can be conjectured that large firms that do not face power outages are likely to have the highest export propensity. Hence, we take this group of firms as our baseline and report the impact of power outages across different firm sizes relative to the baseline. The empirical results indicate that all other firms have lower propensity to export than the baseline case, supporting our conjecture that large firms not experiencing power outages have the highest export propensity. On average, medium-sized firms have a more than 12 percentage point lower propensity to export, while small firms have a more than 22

[17] For brevity, we report only the marginal effect coefficients on the interaction term involving power outages and firm size. All the coefficients are significant at the one percent level of significance.

percent lower propensity to export than the baseline (Figure 7). A comparison across firms of similar sizes shows that firms facing power outages have a three or four percentage point lower propensity to export than firms that do not face power outages.

To check the robustness of our results, we estimate the interaction effect model with other explanatory variables and find that power outages deter entry to the export market and export propensity, irrespective of the nature of firm ownership, involvement in R&D, use of foreign technology, use of foreign inputs and access to formal finance. Firms facing power outages have a nearly 2 percent less chance of entering the export market even if the firms have foreign ownership and access to finance and foreign technology and are engaged in R&D. In the case of export propensity, we find a similar effect, i.e., power outages deter export propensity even in the presence of other favorable factors.

While the WBES database covers a wide range of characteristics that define a firm's operations, the large number of nonresponses to several questions render it challenging to use these variables in the estimation strategy. Many of these nonresponses relate to questions describing the business climate and institutional quality, which are expected to have an important bearing on a firm's performance. In particular, these questions relate to informal payment for various services, business-government relations, indebtedness, among others.

V. Conclusion

The impact of infrastructure on trade has been well documented. However, much of the analysis has been at the country level, whereas it is an individual firm that exports, and country-level analysis can sometimes mask the great degree of heterogeneity that firms can experience within a country. At the same time, many characteristics have been found to make firms more amenable to exports, including innovation, access to finance, foreign ownership, R&D, and productivity. We attempt to fill the gap in these strands of literature by evaluating the role of access to reliable power in influencing firms' decision to export and export propensity. We find that power outages have a significant negative impact on the decision to export, with firms facing power outages having nine to 13 percent lower chances of getting into the export market. Firms facing power outages have significantly lower export propensity than firms that have adequate access to power. Power outages can reduce firms' competitiveness by increasing production cost by forcing firms to rely on more expensive alternate sources of power, disrupt the assembly line and delay production, and create substandard products. Our findings are robust even after accounting for potential endogeneity and other biasedness issues.

Delving into the differential impact across firm sizes, we find that large firms have the highest probability of entering the export market and the greatest export propensity, followed by medium-sized and small firms. Across all firm sizes, power outages have an adverse impact on the probability of entering the export market and on export propensity, with firms that experience power outages exhibiting lower export performance.

Haddad and Shepherd (2011) argued that no major country in the last 50 years has been able to sustain high growth and improve living standards without increasingly integrating into the world market. Increased openness enables firms to access the larger market for their goods, thereby achieving economies of scale in production. Exports encourage specialization and learning-by-doing, which increase productivity not only in the tradable sector but also in the entire economy (Krugman, 1995). Thus, the impact of power outages on hindering exports highlights the need to improve power infrastructure, which will involve bridging the power infrastructure gap and improving the regulatory environment.

Various estimates indicate that, globally, trillions of dollars of investment are needed in the power sector per year. Global Infrastructure Hub (2017) identified the need for investment worth USD28 trillion in the power sector from 2016 to 2040 across major developed and emerging markets. Similarly, MGI (2016) said that global investment of USD14.1 trillion would be needed from 2016 to 2030.

Given the large demand for energy and the position of public finance across most countries, such quantum of investment cannot be funded by the public sector alone and requires the participation of the private sector. Thus, a business climate must be engendered that will foster private sector participation in the power sector, entailing a range of measures that vary across countries. Such a business climate will require setting up a regulatory system that can ensure transparent price discovery, reform of state-owned enterprises to level the playing field for private sector participation, and development of the financial sector to ensure long-term finance for energy projects.

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Annex A

Table A1: Marginal Effect Power Outages and Firms' Export Decision (IV Probit with Conditional Mixed Process Estimator) Controlling for Size Endogeneity

	Dependent Variable: Firms' Export Decision (Dummy)			
	Specification I	Specification II	Specification III	Specification IV
Log Age	0.010***	0.009**	0.010**	0.010**
	0.004	0.004	0.005	0.005
Size (Medium)	0.039***	0.037***	0.038***	0.036***
	0.006	0.007	0.007	0.007
Size (Large)	0.098***	0.109***	0.114***	0.112***
	0.007	0.008	0.008	0.008
Foreign Input	0.001***	0.001***	0.001***	0.001***
	0.000	0.000	0.000	0.000
Power Outage	-0.021***	-0.014**	-0.014**	-0.012***
	0.005	0.006	0.006	0.006
Foreign Firm	0.151***	0.143***	0.143***	0.142***
	0.008	0.010	0.010	0.010
Use of Foreign Technology	0.025***	0.039***	0.041***	0.040***
	0.007	0.008	0.008	0.008
Dummy for R&D	0.021***	0.015**	0.015**	0.016**
	0.006	0.007	0.007	0.007
Access to Finance	0.442***	0.438***	0.437***	0.437***
	0.003	0.004	0.004	0.004
Productivity (Log Sales per Worker)	0.001			
	0.002			
Productivity (KL)		0.000		
		0.002		
Productivity (KLM)			0.001	
			0.003	
Productivity (KLME)				0.005
				0.003
Observation	20633	13763	13274	13124

Productivity (KL) = productivity based on capital and labor, Productivity (KLM) = productivity based on capital, labor and material, Productivity (KLME) = productivity based on capital, labor material and energy, R&D = research and development.

Note: *, ** and *** represent significance at 10, five and one percent level of significance. Country, year and industry fixed-effect included in all the models. Marginal effect is also calculated for the same equation.

Sources: Authors' calculations based on World Bank Enterprise Survey data.

Table A2. Power Outages and Firms' Export Propensity (Heckman Selection Estimation) Controlling for Size Endogeneity

	Dependent Variable: Firms' Export Propensity (Export Sales as a Percentage of Total Sales)			
	Specification I	Specification II	Specification III	Specification IV
Log Age	-3.662***	-2.954***	-2.801***	-2.612***
	(0.812)	(0.941)	(0.941)	(0.942)
Foreign Input	0.113***	0.104***	0.096***	0.094***
	(0.021)	(0.023)	(0.023)	(0.023)
Power Outage	-2.866***	-2.886***	-3.017***	-3.217***
	(0.989)	(1.165)	(1.167)	(1.167)
Size (Medium)	11.349***	10.294***	9.237***	8.717***
	(2.019)	(2.244)	(2.249)	(2.247)
Size (Large)	24.237***	24.714***	23.042***	22.184***
	(3.367)	(3.727)	(3.728)	(3.744)
Foreign Firm	18.890***	16.913***	16.286***	16.147***
	(2.136)	(2.261)	(2.225)	(2.230)
Dummy for R&D	4.662***	5.334***	4.913***	4.501***
	(1.357)	(1.507)	(1.505)	(1.518)
Use of Foreign Technology	3.840***	4.493***	4.294***	4.054***
	(1.208)	(1.471)	(1.470)	(1.473)
Access to Finance	0.345	0.404	-0.089	-0.119
	(1.145)	(1.313)	(1.297)	(1.307)
Productivity (Log Sales per Worker)	1.149***			
	(0.410)			
Productivity (KL)		1.585***		
		(0.472)		
Productivity (KLM)			1.800***	
			(0.535)	
Productivity (KLME)				1.732***
				(0.555)
Constant	-2.510***	-1.702***	-1.693***	-1.703***
	(0.106)	(0.087)	(0.088)	(0.089)
Mills lambda	32.271***	30.483***	28.085***	26.834***
	(4.853)	(4.857)	(4.775)	(4.816)
Observation	18572	12502	12068	11937
Wald-chi^2	1716.34***	1376.98***	1366.31***	1371.58***
Rho	0.837	0.823	0.782	0.758
Sigma	38.524	37.047	35.898	35.359

Productivity (KL) = productivity based on capital and labor, Productivity (KLM) = productivity based on capital, labor and material, Productivity (KLME) = productivity based on capital, labor material and energy, R&D = research and development.

Note: *, ** and *** represent significance at 10, five and one percent level of significance. Country, year and industry fixed-effect included in all the models.

Sources: Authors' calculations based on World Bank Enterprise Survey data.